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JANUARY 1964

THE PLASTIC RESPONSE TO INTERNAL BLAST LOADING OF MODELS OF OUTER CONTAINMENT STRUCTURES FOR NUCLEAR REACTORS

John W. Hanna
William O. Ewing, Jr.

RDT & E Project No. 1M010501A006

BALLISTIC RESEARCH LABORATORIES

ABERDEEN PROVING GROUND, MARYLAND

B A L L I S T I C   R E S E A R C H   L A B O R A T O R I E S

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A B E R D E E N   P R O V I N G   G R O U N D ,   M A R Y L A N D

BALLISTIC RESEARCH LABORATORIES

MEMORANDUM REPORT NO. 1530

JWHanna/WOEwing, Jr./rhg
Aberdeen Proving Ground, Md.
January 1964

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ABSTRACT

Presented are results of an experimental investigation of the plastic response of two geometrically scaled models of nuclear reactor outer containment vessels to internal blast loading. Tests were performed to study the ability of the containment shells to maintain integrity when subjected to large amounts of explosively released energy when unsupported (suspended in air), when half-buried in the ground, and when half-imbedded in concrete. The results show that the vessels tested will withstand a relatively large amount of explosively released energy, as compared to the "maximum credible incident" expected, provided that the welds are adequate and that access or other openings are properly reinforced.

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INTRODUCTION

These Laboratories have been conducting for the Atomic Energy Commission studies in safety of outer containment structures for nuclear reactors. The studies have been both analytical[1*] and experimental with particular emphasis being placed on the response of steel shells of various geometries to internal blast loading. An earlier report[2] gives results of scale model tests of the containment structures with explosives or propellants being used to simulate the scaled down energy releases from nuclear accidents. Results were presented for the elastic response phase of the test, including the effects of partial earth support and a comparison of response to transient internal pressures with strains developed under static internal pressure. One of the objectives of those studies was the verification of the scaling** of the response of the shells to internal blast loading.

In those studies the structural response scaling law <u>was</u> verified for the elastic range. Further, determinations were made of the magnitudes of the dynamic strains generated on the shell surface for a given energy release within the shell.

Because a containment shell need only remain intact to perform its function, it can be allowed to deform plastically under transient pressure loading. Thus, studies of the response in the plastic range are desirable. The present work is a continuation of the early studies into the plastic range and concludes the experimental phase of the investigations.

To verify further the structural response scaling laws, Baker et al[3] had performed a series of experiments on the response of scaled cantilever beams to blast loading from explosive charges detonated in air. The results of those experiments also verified scaling of the response for both the elastic and plastic ranges for these simple structures when subjected to blast loading.

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* Superscript numbers denote references listed at end of report.

** The geometrical scaling law (similarity principle) states that the time histories of displacement and strain of a full-scale model resulting from rapid release of energy from an energy source can be predicted from measurements of these parameters in a scale model of the structure, provided that the scaling factor is applied properly. A thorough discussion of the model laws is given in Reference 3.

However, it is desired (if possible) to test plastic response scaling of the larger (and more complex) containment shell geometries, as well as to determine the ultimate strength of the models under blast loading.

DESCRIPTION OF MODEL SHELLS

The containment shell models used in both the elastic and plastic response tests were all cylinders with hemispherical end caps, of welded construction, fabricated from sheet steel. Figure 1 shows the shell geometry and principal dimensions of each shell in the series. Each of the four shells is a geometrical model of the next smaller shell scaled up by a factor or two. Figure 2 is a photograph of the shells as used in one series of tests.

The shells were all shop fabricated except the largest one (20-ft. dia.), which was field erected. Specifications stipulated that all units were to be made from the same type of steel (i.e., steels having the same elastic and plastic properties). The steel used in their fabrication conforms to ASTM specifications for Type A-283 Grade C. The shells were stress relieved in accordance with procedures outlined in Section VIII of ASME code for unfired pressure vessels.*

EXPERIMENTAL PROCEDURE

For the plastic response studies only dynamic tests were conducted. As in the earlier (elastic response) studies of these models, some of the smaller shells were instrumented with externally mounted resistance wire strain gages, SR-4, Type A-13, mounted at twelve locations. Along the cylindrical center sections, gages were positioned to measure both longitudinal and circumferential strains. Figure 3 shows schematically the strain gage locations.

The shells were subjected to internal transient loading from properly scaled,** centrally located explosive charges (see Table I and Appendix A for charge weights used) and strain-time histories were measured at the various gage positions. The charges were lowered through the small opening at the top of the shell, suspended at the midpoint or below, and then detonated. The

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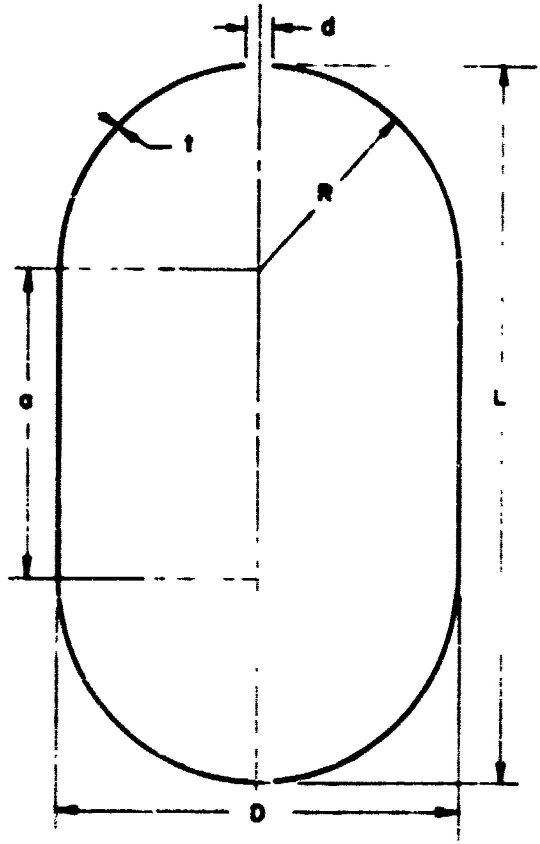
* Low temperature stress relief process, as developed by Linde, was used where required in the field erected vessel.

** The scale factor is two, thus the charge weights increase by a factor of 2^3 for tests of successive sizes of shells.



SHELL NO.	D, FEET	R, FEET	L, FEET	[illegible], FLET	t, INCHES	d, INCHES
1	2 1/2	1 1/4	4 3/8	1 7/8	1/16	2 1/2
2	5	2 1/2	8 3/4	3 3/4	1/8	5
3	10	5	17 1/2	7 1/2	1/4	10
4	20	10	35	15	1/2	20

FIGURE 1 - GEOMETRY AND PRINCIPAL DIMENSIONS OF SERIES OF SCALED CONTAINMENT SHELLS.

FIGURE 2 - SERIES OF SCALED CONTAINMENT SHELLS.

TABLE I

SUMMARY OF TESTS

Shell No.	Test Condition	Range of Explosive* Charge Weights Used (lb.)	Charge Location	Total No. of Charges Detonated	Maximum Charge Before Failure (lb.)	Maximum Simulated Energy Release*** in Full Scale (40'-Dia. Shell) Before Failure (Mw-Sec)	Remarks
1	Shell suspended in air	1/8 - 3/4	Center	9	**	-	Failed prematurely at weld.
		1/8 - 1	20" below center	7	-	-	Failed prematurely at weld.
		1/8 - 1-1/4	Center	8	-	-	Failed prematurely at weld.
2	Shell half-buried in earth	3/4 - 3.84	Center	9	[illegible]	27,885	All original welds replaced. Access hole reinforced. Welded inside and outside. Noticeable bulging at center. Failed by tearing around reinforcement ring in access hole. Numerous vertical cracks around shell.
3	Shell half-embedded in concrete	1/8 - 2	Center	13	1.46	15,754	Failed prematurely at weld.
5	Shell half-buried in earth	5 - 25-3/4	Center	7	14.94	17,393	Failed by tearing initiated at access hole. (little plastic deformation apparent.)

* See tables in Appendices for detailed round-by-round results.

** Premature weld failures.

*** 1 lb. Pentolite = 2.5 Mw-Sec.

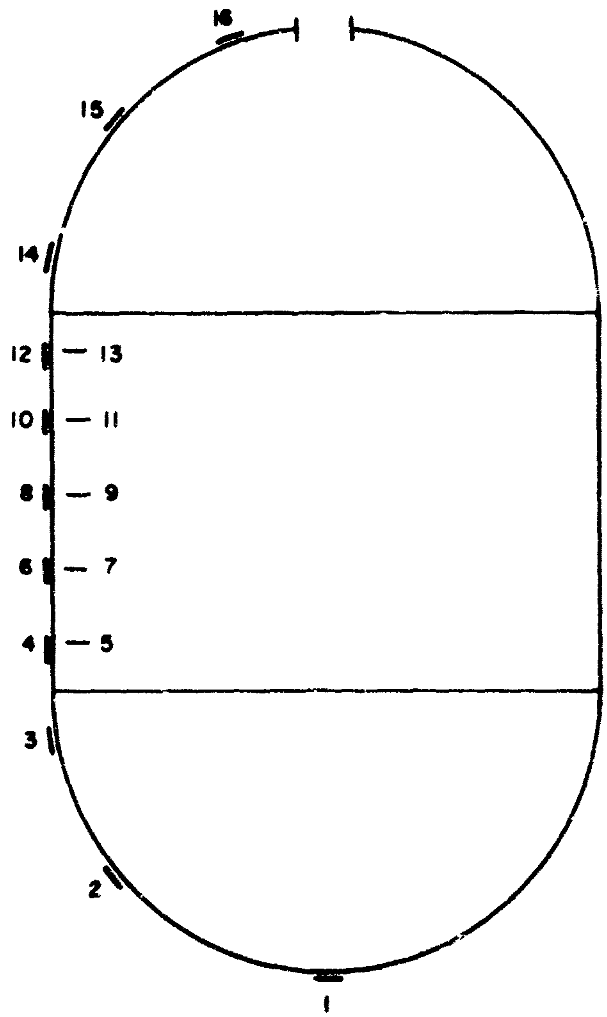


FIG. 3-LOCATION OF STRAIN GAGES ON SHELL

stain-time histories were recorded with a high-frequency response, sixteen-channel, commercial recording system. Small spherical charges of 50/50 Pentolite* were used, the charge weights being increased on successive tests.

Tests were performed with the models suspended freely in air by means of a rope sling (Shell No. 2), with the models partially supported by earth (Shell Nos. 2 and 3), and with the model (Shell No. 2) partially embedded in concrete. The charge sizes used were gradually increased until failure occurred.

INSTRUMENTATION AND DATA REDUCTION

The sixteen channels of strain gage information were amplified by d.c. amplifiers,** displayed on eight dual-beam cathode-ray tubes, and recorded on moving photographic paper. Timing marks and calibration steps are automatically impressed on the photographic record. Peak strain amplitudes (wherever they occurred on the pressure-time trace) were read. Combined calibration and reading errors in measurement of strain amplitudes are estimated to be ± 5%.

TEST RESULTS

The test results are summarized in Table I, while the round-by-round data are presented in the Appendices. Table I indicates the range of charge weights used and location of charges in the models. Indicated also are the maximum charge weights which the models withstood without failing. The predicted maximum simulated energy release (expressed in megawatt-seconds) in a "full-scale" model (80-ft. dia.) shell is also given.

Of the four original models, only Shells No. 2 and 3 were tested in the plastic range. Three specimens of Shell No. 2 ruptured prematurely, the failure occurring at welded joints (see Figure 4). These models were instrumented with strain gages which are capable of indicating strains up to approximately 3%. The gages were used primarily to indicate the point at which plastic deformation began. Acceptable strain-time histories were obtained for most trials and

* An explosive having a heat of detonation of 1220 cal./gm. (Reference DA TM9-1910).

** Having a frequency response flat from 0 to 100 KC.

FIGURE 4 - FAILURE OF CAP WELD - SHELL NO. 2

(before failure of gage leads) for some trials where shell failure occurred. It is to be noted that because of the premature shell failures all strains recorded are in the elastic range. Although detailed elastic response data for these models have been reported earlier,[2] the present data are retained and relegated to the Appendix. After replacing all original welds and reinforcing the access hole with a circular ring in one of the specimens, Shell No. 2 withstood successfully the blast from a series of explosive charge weights up to and including 3 lbs. Plastic deformation of this model was apparent after trial 6. An indication of the extent of deformation can be seen in Figure 5. Two small vertical cracks were observed in the weld at the juncture of upper cap and cylindrical section after detonation of a 3.45-lb. charge. The shell failed when tested with a 3.84-lb. charge (see Figure 6).

In the test of this model while half-embedded in concrete the shell withstood the blast from charge sizes up to and including 1-1/2 lb., but failed prematurely at the juncture of the lower cap and the cylindrical section from a 2-lb. charge.

The larger shell (Shell No. 3), tested when half-buried in earth, withstood the blast loading from charge sizes up to and including 15 lbs. without deforming plastically. The shell ruptured when tested with a 25-3/4- lb. charge. However, failure here was initiated as a tearing at the access hole and is not indicative of the true vessel strength. The only visible indication of plastic deformation was that at the midpoint (ground juncture). Figures 7 through 9 are photographs taken of this model after test. On request from the Atomic Energy Commission (because of possible further use in non-destructive testing), the largest (20-ft. dia.) model was not tested in the plastic range. No plastic tests were performed with the smallest model (Shell No. 1) as all specimens were destroyed in earlier tests.

DISCUSSION AND CONCLUSIONS

Although many of the early trials with the smaller models were hampered by premature weld failures, successful trials were achieved with one specimen after it had been rewelded. The failures appeared to stem in part from incomplete fusion and possibly from inadequate annealing after welding. The relatively thin material of the smaller models had been butt-welded on the outer surface. Further, one cap could be welded on the outside only, since installation of this

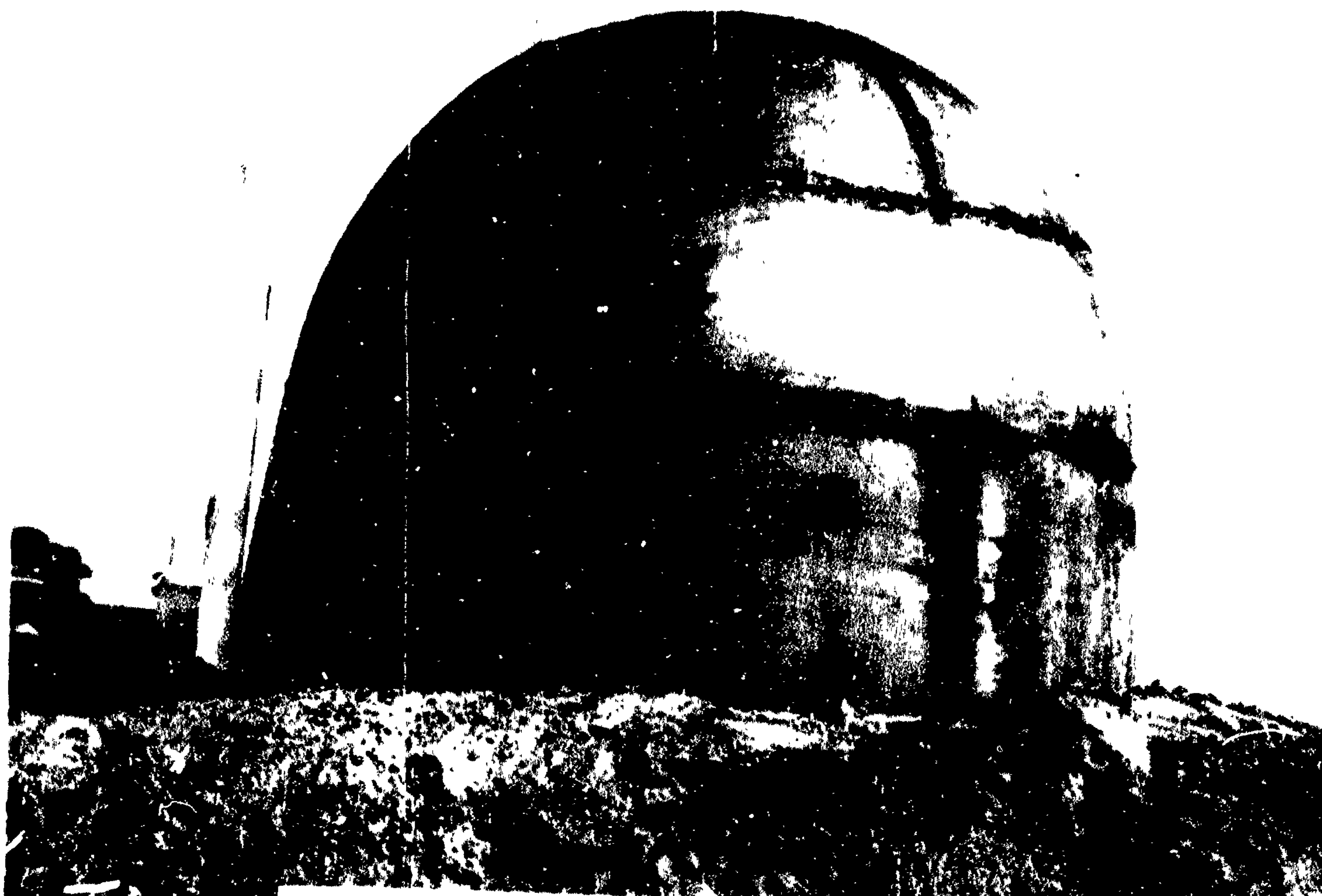


FIGURE 5 - PLASTIC DEFORMATION OF SHELL NO. 2

FIGURE 6 - FAILURE OF SHELL NO. 2

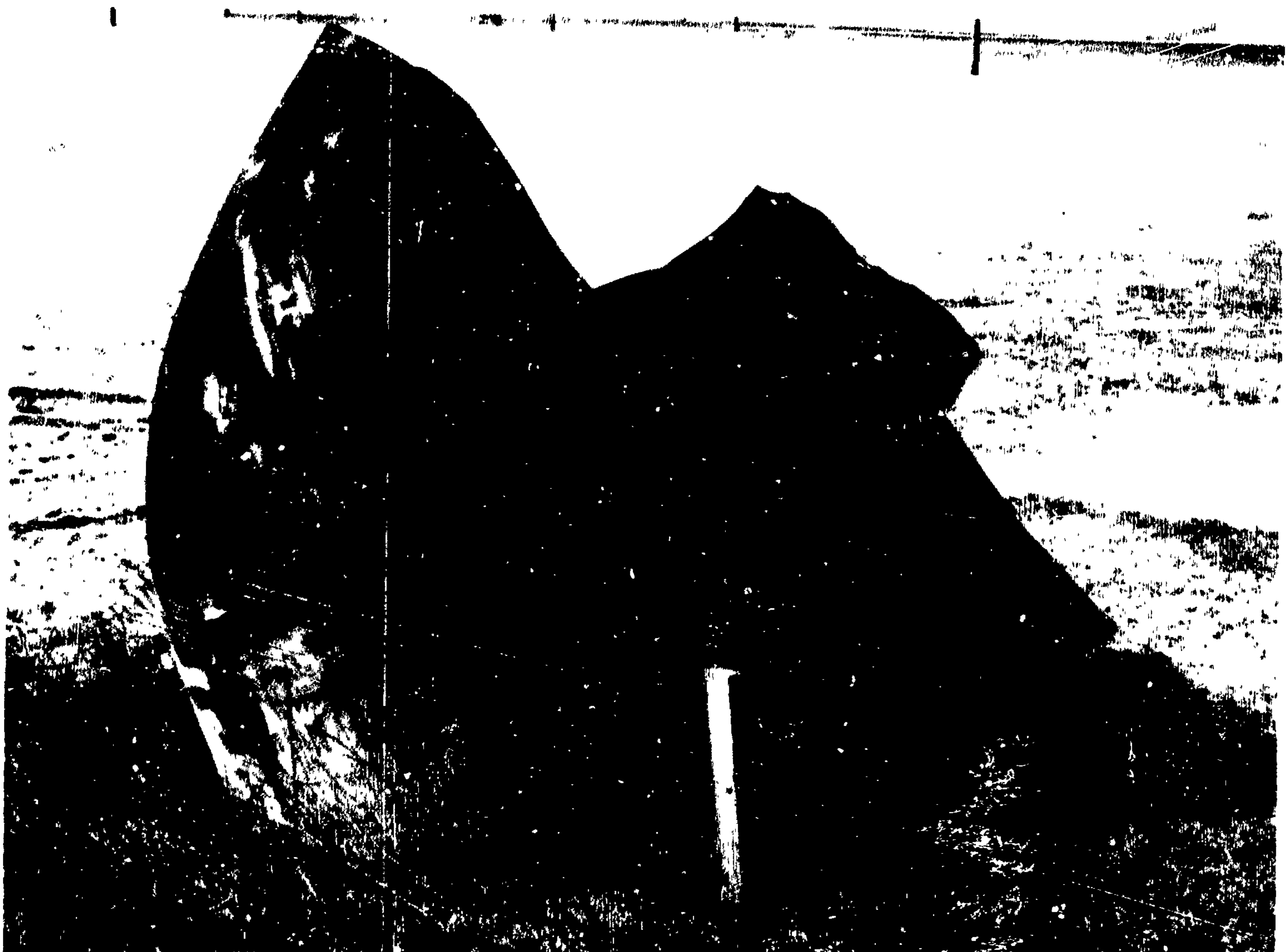


FIGURE 7 - LEFT VIEW OF SHELL NO. 3 AFTER TEST

FIGURE 8 - RIGHT VIEW OF SHELL NO. 3 AFTER TEST

FIGURE 9 - PLASTIC DEFORMATION OF SHELL NO. 3

cap closed the shell. This difficulty was not experienced with the larger vessel because of better accessibility for welding of the interior surfaces.

Although absolute results were obtained with only the smaller model (both access hole reinforced and adequately welded), one can estimate the charge sizes which would be required to cause failure of the larger vessels. The 3-lb. charge which Shell No. 2 withstood is equivalent to 24 lbs. in Shell No. 3 and 192 lbs. in Shell No. 4.

As can be seen from the data in Table I, the vessels of the configuration tested can withstand a large amount of explosively released energy while maintaining integrity.

It is of interest to note that the model sizes were chosen such that the largest shell of the series (not tested in plastic range) is a 1/4-scale model of that of the Air Force Nuclear Engineering Test Reactor.[4*] As can be seen in Table I, the shells tested withstood many times the "maximum credible incident" of 1000 Mw-Sec postulated for this reactor. The adequacy of the shells is more convincing when it is remembered that test results from explosives tend to be "conservative", that is, a structure which will withstand a given amount of explosively released energy will withstand many times the same amount of energy released at a slower rate.[**] One must be assured, of course, that all welds are at least as strong as the vessel itself and that access or other openings are properly reinforced. The cumulative effect of progressive testing on the ultimate shell response cannot be assessed, but it is believed that some degradation is inevitable.

An insufficient number of tests was conducted with eccentrically located charges to enable one to compare results with centrally placed charges. To test rigorously the structural response scaling law for the plastic case, many more successful trials would have been required. However, as stated earlier,

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* A blast effects study of a 1/4-scale model of this reactor was conducted by these Laboratories.

** It is recognized that there are exceptions to this concept. An example would be the case where the pressure generated is allowed to build up in an enclosure and then released (possibly propelling a mass), in which case a relatively higher impulse would be obtained.

the structural response scaling laws have been verified with these models for the elastic range, and with cantilever beams for both the elastic and plastic ranges. Thus it is believed that one can extrapolate with confidence the results obtained here to "full-scale" models.

ACKNOWLEDGEMENTS

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3. Baker, W. E., Ewing, W. O., Jr., Hanna, J. W. Laws for Large Elastic Response and Permanent Deformation of Model Structures Subjected to Blast Loading. BRL Report No. 1060, December 1958.

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APPENDIX A

Round-by-Round Test Results

Plastic Response of Shells

Round-by-Round Test Results

Shell	Trial No.	Test Condition	Explosive Charge Weight (lb.)	Explosive Charge Location	Remarks
2	1	Suspended in air	1/8	Center	
	2	"	1/8	"	
	3	"	3/16	"	
	4	"	3/16	"	
	5	"	1/4	"	
	6	"	3/8	"	
	7	"	1/2	"	3" tear at access hole
	8	"	3/4	"	Both cap welds failed
2	1	"	1/8	20" below Center	
	2	"	3/16	"	
	3	"	1/4	Center	
	4	"	1/4	20" below Center	
	5	"	3/8	"	
	6	"	1/2	"	
	7	"	3/4	"	
	8	"	1	"	Failed at weld
2	1	"	1/8	Center	Rewelded Shell
	2	"	"	"	
	3	"	"	"	
	4	"	1/2	"	
	5	"	3/4	"	
	6	"	1	"	18" long seam opened in top cap
	7	"	1	"	Weld repaired - Top cap separated at weld
	8	"	1-1/2	"	Weld repaired - Top cap failed at weld
2	1	Half-Buried in Earth	3/4	Center	Both caps blown off at welds
	2	"	3/4	"	Rewelded inside and outside and access hole reinforced.
	3	"	1	"	3" long crack in cap segment.
	4	"	1-1/2	"	Crack repaired.
	5	"	2	"	Slight bulging at midpoint of shell.
	6	"	3	"	Increased bulging at midpoint of shell.

Plastic Response of Shells

Round-by-Round Test Results

Shell	Trial No.	Test Condition	Explosive Charge Weight (lb.)	Explosive Charge Location	Remarks
2	1	Suspended in air	1/8	Center	
	2	"	1/8	"	
	3	"	3/16	"	
	4	"	3/16	"	
	5	"	1/4	"	
	6	"	3/8	"	
	7	"	1/2	"	3" tear at access hole
	8	"	3/4	"	Both cap welds failed
2	1	"	1/8	20" below Center	
	2	"	3/16	"	
	3	"	1/4	Center	
	4	"	1/4	20" below Center	
	5	"	3/8	"	
	6	"	1/2	"	
	7	"	3/4	"	
	8	"	1	"	Failed at weld
2	1	"	1/8	Center	Rewelded Shell
	2	"	"	"	
	3	"	"	"	
	4	"	1/2	"	
	5	"	3/4	"	
	6	"	1	"	18" long seam opened in top cap
	7	"	1	"	Weld repaired - Top cap separated at weld
	8	"	1-1/2	"	Weld repaired - Top cap failed at weld
2	1	Half-Buried in Earth	3/4	Center	Both caps blown off at welds
	2	"	3/4	"	Rewelded inside and outside and access hole reinforced.
	3	"	1	"	3" long crack in cap segment.
	4	"	1-1/2	"	Crack repaired.
	5	"	2	"	Slight bulging at midpoint of shell.
	6	"	3	"	Increased bulging at midpoint of shell.

Plastic Response of Shells (Cont'd.)

Round-by-Round Test Results

Shell	Trial No.	Test Condition	Explosive Charge Weight (lb.)	Explosive Charge Location	Remarks
	7	"	3	"	Increased bulging at midpoint of shell.
	8	"	3.45	"	Two small vertical cracks in weld at juncture of upper cap and cylindrical section.
	9	"	3.84	"	Ten vertical cracks around shell at juncture of upper cap and cylindrical section. Reinforcement ring partially torn from access hole. Increased bulging of shell.
2	1	Half-Embedded in Concrete	1/8	Center	
	2	"	1/4	"	
	3	"	1/4	"	
	4	"	3/8	"	
	5	"	3/8	"	
	6	"	1/2	"	
	7	"	1/2	"	
	8	"	3/4	"	
	9	"	3/4	"	
	10	"	1	"	
	11	"	1	"	
	12	"	1-1/2	"	Three 1-1/2" long cracks at access hole.
	13	"	2	"	Shell failed at weld at juncture of lower cap with cyl. section. Upper portion of shell was blown about 200' into air. Concrete cracked on all sides.
3	1	Half-Buried in Earth	3	Center	
	2	"	4.94	"	
	3	"	8.44	"	
	4	"	9.88	"	
	5	"	11.63	"	
	6	"	14.94	"	
	7	"	25.75	"	Shell failed by tearing initiated at access hole.

APPENDIX B

Strain Gage Data

Round-by-Round Strain Gage Data

5-Ft. Capped Cylinder Suspended in Air

Round No. 178
Charge Weight - 3/16 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
1	-*
2	-
3	1400
4	1900
5	1500
6	900
7	2100
8	750
9	1300
10	820
11	1800
12	3900
13	1900
14	-
15	1100
16	900

Round No. 179
Charge Weight - 1/4 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
1	-
2	-
3	1400
4	-
5	1500
6	1050
7	1800
8	1750
9	1700
10	1600
11	1500
12	-
13	1300
14	-
15	1050
16	1500

Round No. 180
Charge Weight - 1/4 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
1	-
2	-
3	-
4	-
5	1000
6	700
7	1200
8	600
9	2200
10	800
11	1700
12	-
13	1200
14	-
15	1600
16	580

Round No. 181
Charge Weight - 1/2 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
1	-
2	-
3	-
4	-
5	1400
6	1100
7	1500
8	920
9	2000
10	700
11	1800
12	-
13	2000
14	-
15	1600
16	2000

*Dashes in these tables indicate that calibration step or trace was not impressed on the record.

Round-by-Round Strain Gage Data (Cont'd.)

Round No. 182
Charge Weight - 3/4 lb.
Charge Location - Center

Gage No.	Peak Strain $\times 10^6$
1	-
2	-
3	-
4	-
5	1600
6	1200
7	2100
8	-
9	2300
10	1200
11	2300
12	-
13	2000
14	-
15	2500
16	1200

Round No. 187
Charge Weight - 1/8 lb.
Charge Location 20" below Center

Gage No.	Peak Strain $\times 10^6$
1	-
2	-
3	710
4	500
5	810
6	-
7	900
8	400
9	-
10	550
11	900
12	570
13	1100
14	620
15	600
16	700

Round No. 188
Charge Weight - 3/16 lb.
Charge Location - 20" below Center

Gage No.	Peak Strain $\times 10^6$
1	-
2	-
3	840
4	1400
5	1000
6	-
7	1200
8	800
9	1300
10	700
11	1100
12	900
13	1300
14	900
15	500
16	1100

Round No. 189
Charge Weight - 1/4 lb.
Charge Location - Center

Gage No.	Peak Strain $\times 10^6$
1	-
2	-
3	1100
4	720
5	1400
6	-
7	1400
8	1000
9	2000
10	930
11	1500
12	1000
13	1400
14	1200
15	640
16	1000

Round-by-Round Strain Gage Data (Cont'd.)

Round No. 190
Charge Weight - 1/4 lb.
Charge Location-20" below Center

Gage No.	Peak Strain $\times 10^6$
1	-
2	-
3	700
4	720
5	1300
6	-
7	980
8	810
9	1400
10	870
11	1300
12	1900
13	1100
14	880
15	810
16	690

Round No. 191
Charge Weight - 3/8 lb.
Charge Location-20" below Center

Gage No.	Peak Strain $\times 10^6$
1	-
2	-
3	800
4	-
5	1100
6	-
7	1800
8	970
9	1200
10	700
11	1300
12	1800
13	1300
14	950
15	700
16	870

Round No. 194
Charge Weight - 1 lb.
Charge Location-20" below Center

Gage No.	Peak Strain $\times 10^6$
1	-
2	-
3	-
4	-
5	3400
6	-
7	3500
8	-
9	2200
10	-
11	2000
12	-
13	-
14	-
15	-
16	-

Round No. 220
Charge Weight - 1/8 lb.
Charge Location - Center

Gage No.	Peak Strain $\times 10^6$
1	510
2	230
3	490
4	400
5	-
6	580
7	-
8	480
9	1300
10	490
11	-
12	350
13	1000
14	400
15	420
16	480

Round-by-Round Strain Gage Data (Cont'd.)

Round No. 221
Charge Weight - 1/8 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
1	710
2	240
3	520
4	500
5	-
6	530
7	-
8	540
9	970
10	440
11	-
12	670
13	900
14	390
15	520
16	510

Round No. 222
Charge Weight - 1/8 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
1	580
2	250
3	530
4	550
5	-
6	610
7	-
8	690
9	1600
10	530
11	-
12	570
13	1100
14	600
15	490
16	1100

Round No. 223
Charge Weight - 1/2 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
1	1700
2	430
3	1200
4	1200
5	-
6	-
7	-
8	1200
9	1300
10	770
11	-
12	620
13	550
14	880
15	940
16	1300

Round No. 224
Charge Weight - 3/4 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
1	1500
2	830
3	930
4	940
5	-
6	-
7	-
8	880
9	1300
10	-
11	-
12	550
13	1300
14	880
15	820
16	880

Round-by-Round Strain Gage Data (Cont'd.)

Round No. 225
Charge Weight - 1.08 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
1	-
2	660
3	390
4	750
5	1500
6	750
7	-
8	940
9	1800
10	880
11	-
12	880
13	2100
14	-
15	1100
16	1200

Round No. 226
Charge Weight - 1.08 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
1	-
2	730
3	1600
4	-
5	-
6	-
7	-
8	910
9	1400
10	830
11	-
12	830
13	1700
14	880
15	-
16	-

Round No. 227
Charge Weight - 1-1/2 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
1	-
2	880
3	880
4	-
5	-
6	-
7	-
8	1300
9	930
10	-
11	930
12	1500
13	-
14	-
15	-
16	-

Round-by-Round Strain Gage Data

5-Ft. Capped Cylinder Partially Imbedded in Concrete

Round No. 207
Charge Weight - 0.12 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
9	630
10	430
11	1300
13	1400
14	480
15	1300

Round No. 208
Charge Weight - 0.25 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
9	900
10	570
11	2300
13	1600
14	630
15	800

Round No. 209
Charge Weight - 0.25 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
9	800
10	920
11	2400
13	-
14	620
15	540

Round No. 210
Charge Weight - 0.37 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
1	-
9	540
10	1000
11	2700
14	880
15	750

Round No. 211
Charge Weight - 0.37 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
1	1900
9	650
10	800
11	2900
14	1100
15	1300

Round No. 212
Charge Weight - 0.52 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
1	3400
9	600
10	600
11	2200
14	760
15	1400

Round No. 214
Charge Weight - 0.79 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
9	800
10	1200
11	2100
14	1700
15	1200

Round No. 216
Charge Weight - 1.07 lb.
Charge Location - Center

Gage No.	Peak Strain x 10^6
9	830
10	1100
11	1800
14	1200
15	1700

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